

COST AND MANAGEMENT

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**Electronics: The
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LOSS

*Official Journal of
The Society of Industrial and
Cost Accountants of Canada*

May, 1955

MANAGEMENT NOTE

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Cost and Management

VOL. XXIX

MAY

No. 5

MAKING A PROFIT PLAN

by EDWARD C. CONLEY 168

Mr. Conley completed his studies in Industrial Engineering at Columbia University. After leaving Columbia, he entered the field of "Industrial Accounting" and has been associated with Gar Wood Industries as a Controller; Ford Motor Company as a Controller in Manufacturing Operations; Willys-Overland Motors as Director of Costs and Budgets, and is currently Controller of Manufacturing Operations at Udylyte Corporation.

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Born in England, Mr. Codd graduated from Oxford University in 1948 with an M.A. (Honours) in Mathematics. He emigrated to the U.S.A., and joined the I.B.M. Corporation in New York, preparing industrial and scientific problems for a large scale computer, later working on specifications for the first high speed computer to be produced in quantity. Early in 1953, Mr. Codd joined Computing Devices of Canada Limited, to head the Data Processing Department.

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William W. Cooper is a professor of Economics and Industrial Administration, Graduate School of Industrial Administration, Carnegie Institute of Technology. He is a Past President of the Institute of Management Sciences, and is a member of the Operations Research Society of America.

Professor Cyert received his Ph.D. from Columbia University, and is now Assistant Professor of Economics and Industrial Administration—School of Industrial Administration, Carnegie Institute. He is serving as Consultant to Touche, Niven, Bailey & Smart, Public Accountants.

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Published Monthly by the
SOCIETY OF INDUSTRIAL AND COST ACCOUNTANTS OF CANADA
Incorporated 1920

Editorial and Business Offices: 31 Walnut Street South, Hamilton, Ontario
J. N. Allan, R.I.A., Secretary-Manager and Editor

Subscription price to non-members, \$5.00 per year. Single copies, 50 cents. Members desiring five copies or more of a single issue, may obtain them at 25 cents. Opinions expressed by articles and comment are not necessarily endorsed by the Society of Industrial and Cost Accountants.

Authorized as second class mail, Post Office Department, Ottawa.

Editorial Comment . . .

ACCOUNTING AND ENGINEERING

A good relationship between accountant and engineer is of vital importance to industry. Both contribute through their individual skills to corporate health and success. They may be termed the two basic professional groups, at least in manufacturing. Once risk capital has been gathered together to form a new enterprise, an accountant and an engineer singly, or in groups go to work to set up the business structure. The one to set up the fundamentals of the economic form, the other to erect the physical plant and machinery. In the resulting interplay of materials, men, and money the two must work closely and well together. A good relationship is, then, of vital importance, not only to industry, but to the accountant and the engineer individually.

They have more in common than they sometimes realize, and much thereby to learn from each other. Take the business of measurement. Measurement is, of course, basic and historic to human progress. It is a means of universal communication and understanding in commonplace things as well as in the sciences. The business of counting is as elementary and fundamental as the alphabet.

Both engineer and accountant measure constantly. The engineer blueprints or sets out a pictorial and mathematic measurement of buildings, machines, and products to be. The accountant by use of balance sheet, and income and expense statement, blueprints or sets forth mathematically and financially, the economic state of the business.

Because measurement is mathematic by nature, we become concerned about such things as standards of measurement, degrees of accuracy and allowable tolerances. The historic bases of physical measurement standards are known to all through such devices as the metric system, and the awkward, if time honoured, English system of inches, feet, yards, and so on. Similarly, money systems as a means of measurement are fixed and familiar.

It is of no importance now, nor does it make the slightest difference how long is a foot, or whether dollars are a good medium of money planning. It is important, that all of us mean the same thing when we use the terms. The ability to use these fundamental measuring sticks or standards, and the capacity to interpret the endless combinations and permutations they take, has created these two great professions.

Accuracy is a common goal for both groups. The very life of business depends on accurate measurement of finances and statistics. It is also a hallmark of the good engineer. Accuracy will probably be defined by the engineer as the measure of the tolerance allowed between parts of a machine, or sections of a building. The tolerance allowed in steel strength in a building design will have a fairly wide tolerance above certain critical low points. On the other hand, tolerances in the thousandths of an inch between the piston and cylinder walls of a gas

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engine will be demanded. The engineer has here a very valuable principle, without which much needless waste of human effort and materials would result. The degree of accuracy must be judged well, but with properly stated tolerances absolute accuracy becomes relative.

Accounting accuracy is a term we are all familiar with, and usually refers to the meticulous accuracy of dollar and cents mathematics as well as the extreme care with which assets and liabilities are stated. No one will quarrel with this program in principle, and it is the bedrock of accounting training and practice to adhere to the fundamental equations that express asset and liability values. There is little, if any, tolerance between profit and loss. We are ahead or behind and breakeven points are usually academic figures of speech.

However, perhaps accounting as a profession might take a look at some aspects of dollar and cents accuracy. Much has been said in recent years about centsless or whole dollar accounting. Is this not a start in the business of relative accuracy, of the use of tolerance? We are rather prone to say that if a thing is not right it is wrong, if not black, it must be white. For a great many uses in accounting measurement a little over or a little under is close enough for practical purposes.

Tolerance! How much tolerance, says the engineer. Might not accountants examine their records in this regard? For example, we set budgets for expense, sales, and every conceivable phase of business effort. This is the measuring stick, the goal, the standard, the accountant prepares and uses for management.

These are carefully calculated, but nevertheless estimates, if intuitive, in the sense that we cannot predict all the changes in economic patterns that can take place. New labour demands, unsteady prices, technological advances, all can change the entire budget or standards picture. There will be differences in both directions before any budget period is over.

Can we apply tolerances here? We submit reports of variances from standard for all elements of costs. Are all of these significant? Many are not, yet we neglect to give, or suggest a safe tolerance, a specified area of measurement over or under budget or a variance on which no action is needed. Conversely, the danger limits should be strongly set out.

The engineer never neglects to establish specific tolerances on all his blueprints. The accountant might well consider doing the same on many of his economic blueprints. Here is a very wide field for thought and improvement in accounting technique.

Reports and statements presented with a suggestion of safe tolerances over and under standard would have much more significance and meaning to senior management.

C & M Round-Up . . .

By N. R. BARFOOT, R.I.A.

How Do You Invest Your Money?

Here is the advice of the financial experts in selecting an investment portfolio of Canadian stocks:

Petroleum	18%
Banks, insurance and finance	16.3
Forest products	16
Metals and mining	15
Retail	8.7
Public utilities	8
Steel and steel products	7.7
Building materials	5.4
Foods and beverages	1.8
Other	3

Most of the money would be spent in Canadian common stock, emphasizing the importance of Canada's expanding economy.

This fact is further underlined by the obvious preference for stocks in the extractive industries and ventures.

It is interesting to note the confidence placed in our banking and finance institutions by investment men.

The above investment plan was worked out not by Canadians, but by astute American investment houses who are investing and will continue to invest up to 100 millions in this country.

The Future for Autos

A recent survey on the possible number of cars on Canadian roads in 1960 shows:

If the present boom continues, an average of 347,000 cars per year will be sold for total registration in 1960 of 4,104,000. Sales in 1953 were 359,172. Registration 2,513,138.

If business proceeds at a more normal rate, annual sales will be 305,000 and ownership 3,809,000.

If economic activity declines car sales will probably drop to 240,000 per annum and registration will be 3,364,000.

Commercial trucks and buses will reach a total of 1,596,000 by 1960 if business is exceptional.

Registration in 1953 was 837,638.

Normal business would mean total ownership of 1,248,000 in 1960.

A decline in business from now on would mean only 998,000 total registration in 1960.

Gasoline to feed all these motors was sold in the amount of 1,903 million gallons.

By 1960 this should reach 4,259 million gallons, with proportionately less if business remains normal or goes into a decline.

C. & M. ROUND-UP

Pension Funds

Some interesting figures are now available on Pension Funds.

Did you know that trustee pension funds in Canada now represent an asset of 1 billion dollars.

The size of these funds, and their net growth mean that the funds will play an important part in the capital market.

Trustee funds are of three types—pension funds, administered by individual trustees—pension funds, administered by trust companies—and pension funds set up in the form of a pension fund society.

Assets of life insurance group annuities in Canada were 398 millions at the end of 1953 with a growth contribution pattern of 52 millions in 1952 and 62 millions in 1953.

In 1953—391,422 Canadians were covered by 260 trustee pension plans—1505 employees per plan.

Life Insurance groups annuities covered 226,507 employees with 2,297 plans or 104 employees per plan.

By 1945 only 76 funds had been established—in 1953—260.

About one quarter of the plans are non-contributory and three quarters were part paid by employees.

The trend is toward contributory plans, prior to 1945 57% of plans were contributory,—of all plans established since 78% are contributory.

Where Do Insurance Dollars Go?

In 1954 investments of the major companies were as follows:

Mortgages	357 millions
Canadian Government Bonds	49 millions
Provincial Bonds	15 millions
Municipal Bonds	17 millions
Corporate and other Bonds	93 millions
Real Estate	27 millions
Policy Loans	12 millions

Mortgage repayments amounted to 139 millions in 1954, making that much more available for re-investment in that field.

Life companies in Canada may invest up to 15% of assets in common stocks but in actual practice only about 3% is so invested.

Taxes, Taxes

The total bill for this year for all levels will be 6½ to 7 billions to 25% of our gross national product.

4½ billion will go to the Federal Government, and 2 billions to the provinces and municipalities.

The Federal income from taxes is distributed as follows:

Personal income tax	1¼ billion
Corporation tax	1 billion
General sales tax	¾ billion

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The balance of $1\frac{1}{2}$ billions comes from liquor, tobacco, tariffs, succession duties, and special Excise Taxes on autos, cosmetics, jewelry, etc.

At the provincial level, the big income is from gasoline tax, 9 cents in Manitoba, 17 cents in Nova Scotia, 11 cents in Ontario, and 13 cents in Quebec. Vehicle licenses, liquor profits, and federal payments make up most of the balance. Five provinces impose a sales tax in addition to the general sales tax by the Federal House.

Where does it go?

At the federal level:

Defense	1.7 billion
Welfare and veterans' programmes9 billion
Debt charges45 billion
Payments to the provinces3 billion

The balance for basic services of any Federal government.

At the provincial and municipal level:

Roads and highways	500 millions
Education	500 millions
Health and welfare	350 millions

The balance goes for police and fire protection, public utilities, libraries, etc.

It is interesting to note that although 25% of the gross national product goes for taxes, in 1939 this only amounted to 16% and in 1929—13%.

PERSONALS

Mr. C. K. Wolff, R.I.A., was appointed Comptroller of Computing Devices of Canada Limited, Ottawa, on April 1st.

Mr. Wm. J. Stookes, R.I.A., has accepted the position of Office Manager and Accountant with Modern Containers, Ltd., 1190 Birchmount Road, Scarborough, commencing May 1st.

Mr. V. E. Feimann, C.G.A., R.I.A., has announced the establishment of his practice as a Cost Consultant.

Mr. Leo J. Burke, R.I.A., has been appointed General Manager for the Halifax-Dartmouth Bridge Commission, and is in direct charge of operating the Angus L. Macdonald Bridge, which was officially opened on April 2nd.

Mr. Harold J. Egan, C.A., R.I.A., has been appointed the Commissioner and Secretary for the Halifax-Dartmouth Bridge Commission.

Making a Profit Plan . . .

By EDWARD C. CONLEY,
*Controller,
Manufacturing Operations,
Udylite Corporation.*

The construction of a Profit Plan which, in the author's opinion, should be the guiding policy of a corporation, is based on a co-ordination of the best-thinking in all major functions of the business.

It should contain the answers to five fundamental questions, and in this article, Mr. Conley examines the methods used to reach the necessary conclusions.

MODERN American businesses are disproving every day, the error of the poet who spoke of the well-laid plans of mice and men often going awry. The successful corporations, especially those engaged in manufacturing, are proving that a Profit Plan will work and, moreover, without such a Plan, the business runs the great risk of floundering and drifting into economic indecision and costly delay.

Constructing a Profit Plan need not be a complicated, involved process. The most important keynote features of any successful Profit Plan must be that:

1. The Profit Plan is the combined, best-thinking of all major functions of the business. All must have a part—engineering, sales, manufacturing, purchasing, finance, industrial relations—with management the cohesive force.
2. The Profit Plan, as it is finally conceived, must be desired by management and agreed upon by management, to the exclusion of all temporary expedients, as the guiding policy of the business.

In a manufacturing enterprise, the Profit Plan should contain the answers to these five fundamental "whats":

1. What will the product be?
2. What sales volume can be expected?
3. What will it cost to produce and market?
4. What will the sales price be?
5. What will it return on the required investment?

How is the Profit Plan prepared? Let us examine a suggested means of reaching the necessary conclusions.

Once management has decided that it will adopt the Profit Plan approach, it establishes due dates for the answers and sub-answers to the five "whats". Management insists that these due dates be followed rigorously. Starting with the date that it desires the product to be available to the customer, it works back to the date when the first step has to be performed. This should be formalized and published in official form to all concerned. (See Figure No. 1).

What Will the Product Be?

Every well-run manufacturing operation has a product-planning group. Some corporations have considered this function of such im-

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portance to vest its supervision in a committee of the Board of Directors. Others have placed the responsibility in a staff group on the executive management level. Whatever its organization, its function is to recommend to management the products to be offered to the customer. There are certain guide posts which could be helpful in arriving at their recommendations. They should be confined to:

1. Products allied with the Corporation's existing line, in order to make maximum economic utilization of present facilities; all around "know-how"; sales outlets and corporate identification. Many a business has faced disaster for failing to heed the old adage about the shoemaker and his last.
2. Products where market analysis and sales contacts indicate demand in harmony with costs and investment.

The product planners, like all other functions of the business, cannot be allowed to operate in a vacuum. They must coordinate their plans with others. This planning function is a process of constant checking with others until the best-thinking of all is utilized. It must get preliminary feels of design, cost, competition, sales appeal, facility requirements, material availability, investment requirements and can do these things only with the assistance and cooperation of other functions. All of this must be performed promptly, and sufficiently in advance, to give all other members of the profit-planning team adequate time to perform their roles in this vital effort.

After the initial phases are completed, the product-planners make preliminary recommendations to management. These are simple in form, but give indication that substantial possibilities exist in the product. The recommendations are the queries for the beginning of the Profit Plan proper.

Based on the aforementioned recommendations, the preliminary work of the Profit Plan is usually sourced to the engineering function. Like all other steps in the Profit Plan, other functions must be constantly utilized. As the product design unfolds, such basic queries as to the saleability of the design; the preliminary estimate of the cost of manufacturing; the production problems involved; the merchandising effort required must be viewed in proper perspective. At this moment, the engineers are charged with the responsibility of producing a product design that will present a minimum of sales and manufacturing problems, and yet, can be produced for a reasonable cost with a reasonable investment. It is important, therefore, that dead-lines to the above described queries be strictly enforced.

With proper screening and coordinating, the engineers produce the product design. This is usually expressed in the form of design drawings and accompanied by tool and operation processing, facility requirements and a Bill of Material. This Bill of Material, with its accompany-

MAKING A PROFIT PLAN

ing specifications, must be an easily understood document. Its use is so extensive and by so many functions and levels, that the simplest possible form should be used. It must answer the questions of "How much of what material." The Tool and Operation Process Forms must also be simple. Modern manufacturing methods are complex enough without adding the woes of difficult instruction forms.

Question No. 1 has been answered. Here, then, is the product. It will look so and it will be made thus.

What Sales Volume Can Be Expected?

Sales people are the corporations' listening posts in the industrial world. To the customer, they are the corporation for they are his contacts with all of the products and product problems. The salesman hears first the stories on quality, price and service difficulties. He learns, before the factory has an inkling, of market penetration. Sales forces rapidly become aware of competitions' advances and new ideas. Most importantly, they know, or should know, the total market for the product and should be able to forecast how much of this market the product can secure.

And so, at this phase, the sales group should be able to forecast, on a reasonably accurate basis, the anticipated volume. In their assumptions, consideration must be given to the merchandising policies which will be employed; the advertising required; limitations of the sales outlets, as well as their potential; and the coverage of the market which the corporation can afford.

What Will It Cost?

All facts are now available to produce a substantially accurate cost estimate. As noted in Figure No. 1, the presentation of cost and profit estimates takes place after the supporting work is finished. Summarizing, the cost estimate can be prepared in accordance with the following table:

Cost Element	Source of Data
Direct Material	Bill of Material priced with assistance of Purchasing.
Direct Labour	Operation processing with assistance of Manufacturing, and Industrial Relations.
Burden	
Fixed	Fixed portion of investment required to produce anticipated volume.
Variable	Manufacturing Budget with concurrence of manufacturing and approved by Management.
Non-Variable	
Tool Amortization	Tooling cost estimate vs. anticipated volume.
Inbound Transportation	Based on sourcing by Purchasing to vendors.

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Administrative Costs **Administrative Budget with concurrence of all administrative functions and approved by management.**

Past experience on comparable products is invaluable in this phase. History of variances from planned costs cannot be ignored and must be pointed up to management. If they have existed in the past and are not contemplated in this cost estimate, justification for their exclusion must be thoroughly documented and made a formal part of the presentation. All other basic assumptions used in the estimate must be similarly explained and agreement reached with all concerned.

What Should the Sales Price Be?

Determining a sales price is by far the most important phase of the Profit Plan. The cost estimate having been accurately prepared, it would appear that by simply adding a mark-up percentage a sales price would be automatic. However, business graveyards are well populated with supporters of this theory.

It would appear if any phase of the Profit Plan needs to be a combined operation then the establishment of the sales price is definitely the one.

One way the problem could be approached would be for:

1. Finance to recommend a selling price based on the relationship of the estimated cost and management's desires as to investment returns. This recommendation would be made at the volume anticipated by Sales. In addition, the effect of increased and decreased volume should be pointed up by Finance. This addendum would aid management in its evaluation of the problem and supply leverage to encourage sales effort, purchasing volume policies and so forth.
2. Sales to express its thinking on the Finance recommended prices at various volumes. At this phase, Sales should know, and be able to accurately document, what the customer price reception will be. Competition must be the all-important guide in sales thinking. Market studies or similar data must be presented to support the Sales position.
3. Engineering to be ready with its plan for designed cost reduction. Improved methods and specifications should be programmed and presented in, at least, estimated form. No product should ever be allowed to become stagnant. It must be constantly improved and revised. It is well said, "There Is Always a Better Way."
4. Purchasing to have available its program for reducing material cost in light of engineering changes and differences in volume, material substitutions and economic changes.

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The above sounds complicated. It need not be. If the proper control of the Profit Plan making is maintained, the above results will be automatic.

With all of these facts before it, management can make its decisions. If the required steps have been followed, its decision can be an easy one to make at this phase. All functions should be available to produce supplementary information rapidly.

What Will It Return on the Required Investment?

No sound business will approach the launching of a product line without exploring the capital requirements of such a program. As with the cost data, all the necessary data is available at this phase of the Profit Plan construction. Briefly, the investment return computation can be tabulated as follows:

Investment In:	Source of Data
Cash	Estimated average amount required at all times for payrolls, material purchases, product tooling payments, fixed asset payments and cash burden items; i.e. utilities, etc.
Tooling	Tooling cost estimate.
Inventories	Based on manufacturing cycle average amount of raw and in-process materials, labour and burden on hand in order to produce anticipated volume.
Fixed Assets	Net book value of fixed assets directly related to the production of the product plus the product's share of general fixed assets; i.e. maintenance equipment, buildings.
Deferred Assets	Estimate of the product's share of prepayments and deferred expense items.

All of the above is related to the estimated profit based on anticipated volume. The resulting dollar amount should then be compared to management's wishes on investment returns.

Making the Profit Plan Work

Management has determined that the Profit Plan will be the guiding policy of the corporation. Like any policy, it will be only as good as its sanction. Performance against the Plan must be constantly and promptly reviewed. The Profit Plan was adopted based on certain basic assumptions as to what each function of the business would do. The internal systems of the corporation must be such that management can sense soft spots early and assist in taking the necessary corrective action.

Finance, the function charged with the identification of profit difficulties, must present most of this data to management. Sales and production volume performance, budget compliance, purchased material costs, labour efficiency, material usage, manufacturing problems

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expressed in dollars—all these, and many more, must be always kept in view. It is the Finance job to keep these facts in the limelight. It is not an easy task and is one requiring extreme tact and knowledge of the other functions' problems. Periodic meetings, preferably terse and well conducted, should be spearheaded by Finance. As soon as difficulties are encountered, remedial action should be instituted before problems are presented for solution, and not just to present problems.

With this approach, a Profit Plan can be a workable, satisfactory management tool.

PROFIT PLAN TIME TABLE

January 5, 1954

From: Office of the President

To: All Concerned

Scheduled Completion Date	Item	Responsibility
1954		
March 1	Preliminary presentation of product to Management.	Product Planning Group
March 8	Preliminary approval by management.	Executive Group
June 15	Product design completed.	Engineering
June 21	Bill of Material completed	Engineering
June 30	Preliminary estimate of anticipated volume.	Sales
July 31	Tool design completed	Engineering
August 16	Tooling sourced to vendors or plant.	Purchasing (assisted by Finance and Manufacturing)
August 31	Tooling cost estimate completed.	Finance and Engineering
August 31	Operation processing completed.	Engineering
September 30	Purchased components sourced to vendors	Purchasing
November 1	Manufacturing budget completed	Finance (with concurrence of Manufacturing)
November 15	Administrative budget completed.	Finance (with concurrence of all administrative functions).
November 22	Investment return submitted to management.	Finance (assisted by Engineering and Purchasing)

MAKING A PROFIT PLAN

November 22	Tentative selling prices recommended.	Finance (with concurrence of Sales)
November 22	Cost and profit estimates presented.	Finance
December 10	Selling prices finalized.	Executive Group
December 15	No. 1 Unit completed.	Manufacturing
1955		
January 6	Public announcement of product.	Executive Group
January 6	Advertising program started.	Sales
January 7	First Units shipped to customer.	Manufacturing

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An important feature has been added to the Technical Sessions in the form of a film presentation entitled, "Electronics for Accounting and Business". This rapidly growing development should be of extreme interest to all delegates.

COST AND MANAGEMENT



The smaller size of Underwood Samas 21 and 40 column punched cards makes them easier to handle. The correspondingly more compact Underwood Samas machines and small, low cost cards take up less space. And in a matter of hours you can have detailed reports on: accounts receivable, accounts payable, inventory control, sales analysis, labour distribution, cost accounting, production control, expense distribution, billing, statistics and market research.

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Electronics: The Impact on Accounting . . .

By E. F. CODD,
Computing Devices of Canada Limited,
Ottawa, Ontario

The advent of electronics in accounting is resulting in a transition period for accountants. It is unlikely that the basic principles of accounting will be altered because of electronics, but there will be a definite impact on procedures. The author feels that, as the use of electronic equipment will in time become a standard part of accounting, it will be necessary for all accountants to have a working knowledge of this equipment.

IN ORDER to appreciate the impact of electronics on accounting, it is necessary to be aware of the various kinds of electronic machines which are now available for accounting work, to know of some of the uses to which these machines are now being put, and generally what their capabilities are. We are still, of course, at a comparatively early stage in applying electronic machines to accounting procedures and consequently, general statements about their application and usefulness must, of necessity, be guarded. I shall endeavour to make a careful distinction between actual achievements on the one hand and possibilities and opportunities on the other hand.

As a means of introducing the main properties of digital computers, I propose to discuss various types of records, and to start with the most familiar of these in business, namely paper records. This type of record is today still the most used medium for processing information within an organization as well as for communication between that organization and its customers, suppliers, etc. Of course in the last quarter of a century, various other means of storing information have come into use though really they have made a very small dent in the amount of paper documents still used. Examples of these newer means for storing information are:

- Punched cards
- Punched paper tape
- Embossed plates
- Microfilm

For written paper records, both human recording and human reading are necessary. In fact, to copy the information requires a human being unless photographic means are resorted to. Punched cards and punched tapes on the other hand are normally interpreted by machinery and the information in them can be duplicated quite automatically. However, suppose we need to change some of the information on any of these records, you will notice that none of them possess the all important feature of erasability. You know that if you want to change a column of a card you have to punch another card. Now you can see the first benefit of electronic digital computers.

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These machines contain facilities for storing information in such a way that any or all of it can be erased and changed at will. Such facilities are normally referred to as memories. A very commonly used type of memory is the magnetic drum. In this memory, information is recorded in magnetic form on the surface of a rapidly rotating metallic cylinder. This cylinder rotates inside a casing on which are mounted electrical elements known as read-write heads which record or pick up the information on the drum. The pattern of magnetic recording is such that information can be recalled completely unchanged—a necessary property of any memory to be used for business purposes. Generally speaking, the larger the drum the more information it can hold on its surface. Magnetic drums are now available with a memory capacity of as much as 100,000 decimal digits. In addition to capacity, an important characteristic of any machine memory is its speed of access. By this is meant, how fast can one obtain any desired piece of information from the memory. With magnetic drum memories speed of access is largely determined by how fast the drum revolves. A typical average access time for a magnetic drum is 10 thousandths of a second. Apart from their use as components in general purpose data processing systems, magnetic drums are now in use in a number of special systems. For example, at the Toronto Stock Exchange, there is a bid-asked system in which the bid and asked prices of the various stocks and shares are recorded on a magnetic drum. As a result one can obtain up-to-the-minute information on a particular stock by merely dialing the code for that stock. Another example is the use of two large magnetic drums by American Airlines for recording reservations on flights departing from and arriving at New York. Other magnetic drum systems are being used in several department stores and also in a mail order house in Chicago, to keep an up-to-the-minute tally of items in stock.

A question that frequently crops up in connection with these machine memories is this: "How do you know what information you have got in the memory?" You certainly cannot see very much by looking at the drum, even if it were not mounted in an opaque casing. The information content of such a memory is normally revealed by means of an electrically operated printer, such as a punched card tabulator or a tape-operated typewriter. Another question is: "How can you have confidence in invisible recording of important information?" I believe that only experience in using this kind of a memory will give the necessary confidence.

Now let us turn to a different type of machine memory. Again, it is magnetic, but this time it is transportable or removable from the machine. I am referring to magnetic tape. The magnetic tape used for data processing systems differs little in appearance from that used for sound recordings, but the form of recording is entirely different. As with the magnetic drum, the information is represented by discon-

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tinuous geometrical patterns of magnetization, rather than by continuously variable magnetization, so that unlike sound recording, exact recall is possible. The information capacity, the compactness and speed of magnetic tapes are well worth noting. An average magnetic tape is about 1500 feet long and can store anything from a million to two million decimal digits—or in terms of punched cards from 12,000 to 24,000 fully punched cards. Such a tape is normally wound on a reel one foot in diameter. It is possible, therefore, to reduce the physical size of files whether of paper records or punched cards by transferring the information to magnetic tape and setting up a rack of magnetic tape reels. As far as speed is concerned, a typical reading or writing speed is equivalent to 150 cards per second. One organization which has already set up magnetic tape files for what might be termed business data, is the U.S. Naval Aviation Supply Depot in Philadelphia. The application is essentially inventory control.

When a magnetic tape is being referred to by data processing system, it is mounted on a magnetic tape unit. Several such units may be included in a single data processing system, the actual number being determined by the type of work to be done. A typical inventory control application requires one or more tape units for recording an analysis of movement of stock. In an inventory of products for example, this analysis would be the sales analysis. When a payroll job is being done, at least one tape unit would be used for information relating to each employee: for example, rate of pay, tax exemption, deductions of various kinds, any information in fact which does not normally change from one pay period to the next. Another tape unit would be used for recording a cumulative history of payments. Other uses of magnetic tape are for storing customer records when billing or processing accounts receivable, suppliers' records when processing accounts payable and job records for cost accounting.

So far we have dealt almost exclusively with memories and consequently, only the record keeping function of data processing has received its due attention. Other important functions involved in data processing are correlating, computing, and reporting. Correlating brings to mind such things as file maintenance, sorting, merging, matching, etc. The ability of the electronic computer system to carry out these operations is based upon its capacity to make choices providing the criteria are specified in advance. Two items of information can be compared, and on the basis of which one is the larger or whether equality exists between them or not, either one course of action will be followed or another. If, then, we have production records in order by man number on one magnetic tape and we require them to be in order by job number on another magnetic tape the system has the ability to carry out this re-arrangement completely automatically.

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Little need be said about the computing ability of electronic computers because so much stress has been put on this aspect that many people have the impression that this is all these machines can do. We all know how complex problems have been, and are being, solved in such fields as ballistics, aerodynamics and nuclear research. What is sometimes overlooked is the fact that the method of solving these complex problems is by breaking the problem down into extremely simple calculations—calculations which in fact involve only those elementary arithmetic operations which are necessary to accounting. Consequently, a machine which has been used on some problem in astronomy, for example, should not be ruled out on that account for business use.

One aspect of the use of electronic computers in business which was overlooked until recently, was that of proper presentation of processed information, which I referred to as reporting. By "proper", I mean according to law, well established custom, or expediency. As a result of the considerable development work which has been done, there are now available reporting devices with very great flexibility in format control, and with a wide range of speeds of operation. The fastest printers are currently being used by insurance companies for premium billing purposes.

Perhaps the most troublesome aspect of data processing, whether it be manual or mechanized, is the planning of work flow. That is, insuring that all the various operations are carried out in the right sequence and at the right time. The extent to which it is possible to set up an electronic machine to take care of this aspect shows up a marked contrast between certain different types of machines. The general purpose electronic computer system which is equipped with magnetic tape units is capable, first of all, of storing very long sequences of instructions which the system is to execute. And secondly, it can follow through the execution of these instructions without any human interference. The usefulness of this feature can be seen if we consider three operations which are normally regarded as separate, but on equipment such as this become fused into one. The operations to which I am referring are: inventory control, sales analysis and invoicing. In this example, we feed into such a system information concerning withdrawals from, or additions to, the inventory. Corresponding changes are made in the stock levels recorded on magnetic tape, appropriate sales statistics are adjusted on another magnetic tape and invoices or receipt forms compiled. Since these machines have to be instructed in great detail as to what is to be done with every piece of information with which they are presented, such a procedure requires a fairly long list of machine instructions.

Now various kinds of electronic computer systems are available which are not as truly versatile as the general purpose system which includes magnetic tape units. They may be limited either through lack

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of adequate memory for instructions, if they are machines in which instructions are internally stored; or they may be limited in virtue of the fact that the instructions are represented externally by plugboard wiring, for example, or even by the manual setting of switches. This is not to say that such machines are not useful, but only that their area of application is limited.

Variation in cost is considerable. You may pay anything from \$30,000 to over a million dollars on an outright purchase, and rentals vary to a corresponding degree.

It is natural perhaps that the insurance companies should have pioneered the use of electronic data processing machines for business use. However, the stage has now been reached where manufacturing concerns, for example, General Electric at their plant at Louisville, Kentucky, are using machines of this type for accounting work. During the next year or so, we shall see many more manufacturing concerns, also department stores, mail order houses, railways, utilities, oil companies, etc., using this type of equipment. Right now several hundred such machines are on order on the North American continent, by organizations wishing to use them for accounting purposes.

What sort of changes will they bring about in accounting procedures and more generally, the field of accounting? First of all, I believe there will be no change whatever in the basic principles of accounting. There will, however, be a considerable impact on procedures. It will be practical for example to determine the state of one's business, not once per year, but many times and in some cases, daily. The art of reporting to management, and also the kind of reports which management expects, will undergo considerable change. Not only will it be possible to present reports much more frequently than heretofore, but also each report will contain much more information in less volume. The condensation of reports will be possible in view of the greatly increased analytical ability both of machines and of the accountants who instruct them. Prediction and scheduling will become important parts of the accountant's responsibility. Finally, data processing equipment will become so much a part of accounting that it will be necessary for all accountants to have some degree of familiarity with this equipment.

FOR FURTHER READING

- DISTRIBUTION OF OVERHEAD WITH ELECTRONIC COMPUTERS—H. T. Ashman, N.A.C.A. Bulletin, Feb., 1955.
THE GAP BETWEEN THE ELECTRONICS ENGINEER & THE ACCOUNTANT—Paul Kircher, The Controller, Aug., 1954.
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Operations Research . . .

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In this paper, the authors explain the relationship of Operations Research to the broader aspect of Management Engineering, and illustrate its application to certain managerial and accounting problems such as Chemical Processing and Production Scheduling, verification of vendor's invoices and department store receivables.

IT WOULD be helpful in explaining the subject of operations research to a business audience, if it were possible to draw on a single definition which was at once authoritative and satisfactory. The new profession of operations research has not yet been able to evolve such a definition. A plethora of attempts at definition have been essayed, but many of them are likely to prove confusing to the uninitiated. They seem to be directed toward helping the operations research practitioner rather than toward bringing others outside the profession to a better understanding of O.R. As such, these definitions and their accompanying discussions are likely to prove more illuminating to persons versed in the ways of science than in the ways of business.

Operations analysts¹ have tended to emphasize the novelty of their approaches and to contrast or otherwise distinguish themselves from previously existing commercial practices and disciplines. This paper will attempt to alter this emphasis. So far as possible, an effort will be made to view operations research in relation to previously existing disciplines and practices. Particular emphasis will be placed on its relation to the field of management engineering.

2. OR and Management Engineering

A discipline may be defined by reference to the problems (or subject matter) with which it is concerned, or by reference to the methods (or tools) that it uses.² It will be helpful to consider OR (or operations research) from both points of view. OR may then be viewed as part of the normal course of development in the field of management engineering. The validity of this proposition can most easily be established by reference to the types of problems with which management engineering has become increasingly concerned. The tools employed by the operations analyst, however, differ in important respects from those employed by more traditional practitioners of management engineering. Indeed, this difference will be used in this paper to provide a means for distinguishing OR practitioners from others in the field of management engineering.

* The material on accounting and statistics is drawn from a broader study of the application of statistical techniques to accounting and auditing problems being carried on at Carnegie with the co-operation of Touche, Niven, Bailey & Smart, Public Accountants. The authors also wish to acknowledge the aid of A. Charnes, W. R. Taaffe, and Robert M. Trueblood.

¹ This term will be used interchangeably with the term "practitioner of operations research."

² John Dewey, "Unity of Science as a Social Problem", in INTERNATIONAL ENCYCLOPEDIA OF UNIFIED SCIENCE, Vol. 1, No. 1, (Chicago: University of Chicago Press, 1938), pp. 29 ff.

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To comprehend OR from this standpoint it is, of course, necessary to view management engineering in broad terms.³ Consider the implications, for example, of viewing the engineer as an "applied scientist" with the duties of maintaining close contact with advancing scientific knowledge and of assessing and adopting this knowledge for practical applications. OR may then be regarded as a development in management which is paralleled (even to the wartime acceleration) by developments in other fields of engineering—such as electronics in electrical engineering, supersonics in aeronautical engineering, etc. In each field these developments represent not only the impact of new substantive knowledge, they also represent the impact resulting from the evolution or importation of new and more powerful tools. These tools were required by the increasingly complex problems which the engineers in these disciplines were confronting.

A trend has long been in evidence for management engineers to be concerned with broader ranges of problems than those represented by traditional time, motion and method studies. Problems in accounting, finance, marketing, personnel evaluation and placement, and organization planning and budgeting have received increased amounts of attention from management engineers. These engineers have expanded their area of activities from a manufacturing base to include retailing and wholesaling, government agencies and even military programs. In areas of application and in types of problems, the management engineer and the operations analyst (possibly with some difference in emphasis) occupy a common ground.

Having noted this common core of interests it may be well now to turn to some of the differences between the modern operational analyst and the traditional management engineer. It is conceivable that an operations analyst might, for example, be employed to make a method and time study of a characteristic manufacturing operation.⁴ It is hardly likely, however, that he would go about the assignment in the traditional manner of management engineering or arrive at the same result. The difference lies in the methods that the OR specialist would employ.⁵

³ For a discussion of Taylor's original concept and the subsequent development of management engineering see Harold F. Smiddy and Lionel Naum, "Evolution of a 'Science' of Managing In America," *MANAGEMENT SCIENCE*, October, 1954.

⁴ See, for example, the discussion of the Morton Manufacturing Company in the operations research case studies released by Arthur D. Little, Inc. (Memorial Drive, Cambridge, Mass., U.S.A.). In this case a probability analysis succeeded where standard methods of setting times for a stamping operation failed because of the need for machine adjustments and possible "machine interference" arising from the need for multiple adjustments materializing at the same time. Verification of the times was obtained by employing snap readings on tours at randomly selected times as a device to avoid the difficulties of ordinary time study methods including the lack of confidence that the workers had developed in such standard methods by prior applications.

⁵ See Cyril C. Herrman and John F. Magee, "Operations Research for Management", *HARVARD BUSINESS REVIEW*, July-August, 1953, particularly the remarks on OR and industrial engineering methods.

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A mark of the good operations analyst is his familiarity with the frontiers of advancing knowledge in such fields as mathematics and statistics as well as in the fields of engineering and management. Applications of statistical sampling theory, search theory, queuing theory, linear programming, game theory, and related areas are regarded as natural rather than exceptional or artificial aspects of his work. Many of these applications require versatility and originality on the part of the analyst. Hence, the good OR practitioner must be versed in these sciences in a way which will lead naturally to contributions to the underlying disciplines themselves. Young though the profession of operations research may be, there is already a fair amount of evidence pointing in this direction. This two-way relation between the basic sciences and engineering has become increasingly a quality which is present in other fields of engineering. It therefore seems appropriate that management engineering, sparked by OR, should also develop in this direction.

The fact that OR and more traditional fields of management engineering are distinguished primarily by their tools and methods of approach should not be interpreted to mean that the differences between the two are unimportant. On the contrary these differences are profoundly important. They involve not only a marked difference in point of view, but also a marked difference in the relation of this phase of engineering to scientific endeavours. As has been suggested in the preceding paragraph, the OR worker is not only in a position to take advantage of accelerating scientific developments, he is also in a position to furnish stimulation and guidance to these developments.

The point may perhaps be sharpened by considering the directions in which OR is likely to stimulate and guide such scientific developments. The chief OR tools (over and beyond those of traditional management engineering) are statistics and mathematics. In both statistics and mathematics the operations analyst has been able to secure the advantage of scientific advances which could be adapted to many problems in business and government. In problems of data collection, interpretation, and analysis the OR worker has thus been supplied with general, powerful, and precise tools which have enabled him to deal with mazes of complexity or subtlety which might otherwise have proved overwhelming.

But provision of such tools will not, alone, be sufficient for sustained progress in operations research. Neither statistics nor mathematics is, by itself, sufficient. It is becoming increasingly clear that the effective employment of these disciplines for OR problems will require a scaffolding of abstract or conceptual models of concrete situations. Construction of such a scaffolding cannot be undertaken by science alone. It will require, also, the efforts of OR workers who have become intimately familiar with business (and government) institutions and

problems as well as with scientific knowledge, attitudes and procedures.

Examples of OR Work

The methods of operations research, its mode of organization and the kinds of models it employs can perhaps best be understood in the context of familiar types of business problems. A start may be made by discussing an actual example drawn from the field of accounting. This will be followed by an illustration compiled from actual accounting data for the purpose of illustrating certain statistical principles. Attention will then be directed to another OR tool, linear programming, in the context of a freight scheduling problem. References to applications in other fields such as chemical processing and production scheduling will also be discussed.

An OR Application of Statistical Sampling Methods to a Problem in Accounting

a. *Verification of Vendors' Invoices*

The particular study to be discussed involves the development of a statistical sampling scheme for verification and control of vendors' invoices. Before describing this example, however, it may be well to pause and consider the place of the special services staff in a public accounting firm in order to align the present discussion with preceding sections of this paper. Such special service units are coming into increasing prominence among public accounting firms. The staffs of these units are intended to supply ancillary services (in addition to the services provided by regular accounting and audit personnel) and to ensure a more effective merger of accounting and management. These units are frequently staffed by persons with combined industrial and engineering backgrounds so that they may be fairly characterized as management engineers. They thus fall into the evolving pattern of relations between management engineering, business practice and OR which was described earlier.

These special service units also provide a type of person who may easily and with great value, be integrated into an OR team, as will become clear in discussing the present example. Among the problems considered by the special services unit in this public accounting firm, was one involving the possible application of statistical sampling procedures in order to assist one of their clients, a very large fabricator, to develop more effective and economical procedures for the control of vendors' invoices. The firm in question had been following the practice of paying vendors' invoices upon confirmation by a valid purchase order. Control was secured by subjecting these invoices and accompanying documents to 100% review and audit. This involved checking each invoice for accuracy of prices and quantities, correctness of footings and extensions, etc. An average volume of some 50,000 invoices per month entailed the services of a substantial clerical staff to maintain this procedure.

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The first step in this study of the applicability of statistical sampling methods was to form a team composed of a public accountant (with training in management engineering and statistics) drawn from the special services staff; an internal auditor drawn from the staff of the industrial firm who possessed a good knowledge of the firm's problems, organization, and operating procedures; and a statistician with training and experience in handling accounting data. Although not a feature which is unique to operations research, such teams, or task forces, it should perhaps be noted, are characteristic of OR work. The team in this case was designed to supply knowledge of the firm and its practices, knowledge of the relevant accounting and auditing problems (as well as practices in other firms), and knowledge of the (possibly) relevant techniques which might be drawn from mathematics or statistics.

The team's first concern was to devise a means for matching costs and benefits resulting from current procedures. A break-even chart plotting the costs against invoices of various sizes and plotting also the savings from mistakes discovered on invoices of various size was made, using data for several months picked at random. The results of the break-even analysis made it clear that it did not pay to audit invoices under \$1000, provided certain conditions were maintained. The costs, in other words, were greater than the derived benefits for invoices less than \$1000. Therefore, the logical decision was to forego the audit of the invoices under \$1000.

However, it is necessary to maintain control of the invoices because it is always possible for such situations to change. The proportion of errors or the size of the errors might increase to the point where the benefits from a 100% check would exceed the costs. It is for a control problem of this type that certain sampling methods based on the laws of probability can be utilized.

By using modern sampling techniques it is possible to estimate the proportion of errors and the average size of errors. By using certain probability concepts it is then possible to determine, not with certainty but rather with a stipulated probability of being wrong, whether or not the universe has shifted to the point where 100% inspection is necessary. Application of these probability concepts revealed that a suitably drawn sample of 600 invoices would in this case prove adequate to supply the desired control estimates.

Clearly it was the task of the OR technician to recognize and adopt suitable statistical implements for this assignment. But this would not have been sufficient. A vital part of these studies depended on adequate provision of accounting insights and ingenuity in altering the existing system to meet the requirements of probability sampling. An interesting example of the fruitful interplay between accounting and statistical requirements in this OR study is provided by the provision of

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a system for classifying vendors. Accounting considerations and experience suggested that it was probably the case that relatively few vendors constituted large sources of errors. It was suggested, therefore, that a classification system might be developed which would provide a convenient basis for subsequent analyses of these factors. The system could also then be arranged to admit of certain advantages in the employment of statistical methods. First, if sample data indicates possible changes in underlying conditions, recourse may be had to these particular vendors without necessarily requiring 100% inspection of all invoices. Second, these subsequent analyses may indicate desirable alterations in sample designs. Instead of sampling the invoices, directly, a "two-stage" design might be employed. A sample of vendors might be drawn on a probability basis, and then a second stage of sampling be introduced by selecting only a portion of the invoices submitted by these vendors. Preliminary analyses of the relevant statistical properties indicated that such a two-stage sample would yield advantages in contrast to a single-stage sample of the invoices directly.

Certain salient features of this project might be noted. In contrast to some of the often-cited examples drawn from wartime military experience, this team was not composed wholly of OR specialists drawn from the ranks of science. An advantage was derived from the fact that two members of the three-man team were drawn from regular business ranks. One of these persons (supplied by the firm in question) possessed a detailed familiarity with the firm and its problems; the other (drawn from the public accounting firm) possessed general familiarity with this kind of problem, and the approaches that had been developed by other business firms.

It might be said that these two individuals supplied, from their judgment and experience, the elements from which the OR specialist could develop his model and secure guidance in his choice of statistical tools. It was the OR specialist's responsibility, also, to know what kinds of tools modern science might have available for the tasks at hand and to employ these tools to maximum advantage. He acted as the fulcrum, so to speak, by means of which the knowledge of modern science could be brought to bear on this particular operating problem just as the other two team members provided a similar fulcrum for the accumulated knowledge of business practice.

b. Application of Statistical Sampling Methods to Department Store Receivables — An Illustration

It may be well at this point to elucidate the meaning of some of these remarks on statistical methods by reference to an illustrative example. Table 1 portrays a *universe* or array of totals, by ledgers, for accounts receivable in a certain department store. In this case the total value of this universe (of accounts receivable) is known. Moreover, if desired, further classifications and analyses of this universe could be

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undertaken. It might be desired, for example, to know whether or not these ledger values are distributed approximately "normally"—i.e., in the form of the familiar bell-shaped curve. This could be done by plotting, e.g., a histogram or bar chart for appropriate groupings or classifications of ledger values. The resulting graph would provide a distribution for the universe indicating the proportion of the total universe value (\$605,533) which each subclassification of ledger totals accounted for.

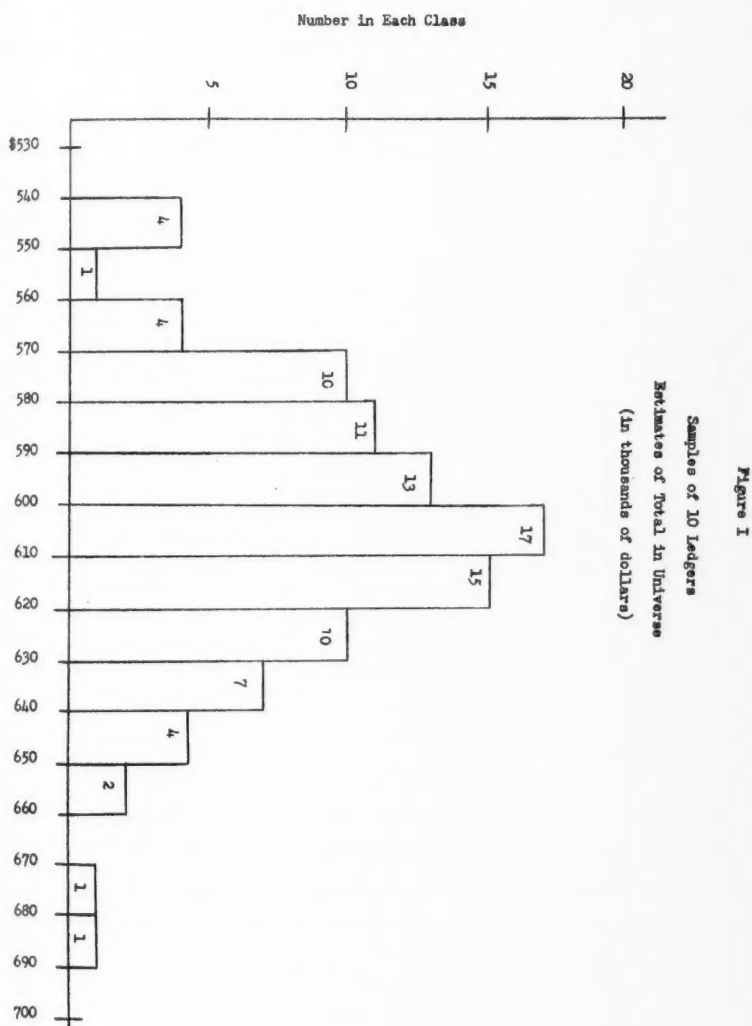
Suppose, however, that neither the universe total nor the universe distribution were known. Could sample evidence be employed to determine (with measurable error) the universe total and possibly other attributes of the universe as well? An answer is supplied by modern statistical theory. A general theorem of statistics states that if samples (of sufficiently large size) are drawn repeatedly at random and averaged, these averages will tend to be distributed according to the normal or bell-shaped distribution, even if the universe of original values is not. This theorem is known as the central limit theorem for averages. It is valid under very general conditions, provided the samples are of a suitable size. Thus the theorem enables its user to refer to prepared tables of the normal curve in order to make quantitative inferences concerning probable relations between sample and universe values even when nothing is known initially about the latter. Statistical theory also supplies formulas for making the estimates and deciding the size of sample necessary to achieve any desired reduction in this error.

An experiment was performed with these data as follows. One hundred samples of ten ledgers each were drawn at random and their averages calculated and recorded. By reference to the central limit theorem, it is possible to predict, in advance of the drawings, that the estimates of the universe value derived from these averages would yield a histogram (or sampling distribution of these averages) which would have the following attributes: (a) It would appear to approximate a normal distribution and (b) the distribution would tend to centre symmetrically about the true universe value, \$605,533.

It would be possible to predict certain other features of these sampling distributions as well. Sample data could be used, for example, to estimate the tendency of the ledger totals to scatter or spread around their average value. From this knowledge it would be possible to determine for any given size sample the proportion of case (upon repeated drawings) which would fall within any prescribed range of the true universe value. The potential range of variation of sample values can be used with the assistance of suitable formulas drawn from statistics, to estimate the "true" universe value from sample data and to compute the error of the resulting estimates—viz., the probability that the true universe value will be entirely missed. The range of variation, or

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tendency of sample values to scatter, can be determined by reference to sampling distributions of the kind portrayed in Figure I.



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TABLE I

Universe of Ledger Totals

Ledger Number	Ledger Number	Ledger Number	Ledger Number
1	\$10,811	31	\$ 9,534
2	13,977	32	11,453
3	10,167	33	10,432
4	10,956	34	11,211
5	9,983	35	9,474
6	16,026	36	8,774
7	9,468	37	11,338
8	11,362	38	10,644
9	10,034	39	11,779
10	9,281	40	10,438
11	9,395	41	10,853
12	10,221	42	8,211
13	10,873	43	11,244
14	8,611	44	13,698
15	12,795	45	10,841
16	11,436	46	8,753
17	8,342	47	10,067
18	8,882	48	12,325
19	10,731	49	12,039
20	8,192	50	12,147
21	12,541	51	9,013
22	8,844	52	9,441
23	12,420	53	10,479
24	11,098	54	8,476
25	8,050	55	9,029
26	8,100	56	8,871
27	8,754	57	7,125
28	9,922	58	9,561
29	9,877	59	9,541
30	7,593		

This sampling distribution refers to a particular example—the universe of ledgers—and a particular sample size and method—viz. ten ledgers drawn at random from the universe of 59 ledgers and replaced prior to the next drawing of 10 ledgers. Changing the sample method or the sample size will alter the nature of the sampling distribution and so provide a different application of the central limit theorem. Again the results are predictable from statistical theory.

Increasing the size of sample would tend to reduce the error. Expansion in the sample size would cause the sampling distribution portrayed in Figure I to “bunch in” and cluster symmetrically about the true universe value of \$605,675.45. Credence may be lent to this point,

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perhaps, without additional analysis by considering how the resulting sampling distribution would appear if samples of 59 ledgers were employed. In this case the sampling distribution would shrink to a vertical line at the value of \$605,533 and all *sampling* error would then be eliminated from the estimates. The process of "bunching in" suggested by the central limit theorem may be thought of in terms of the successively less scattered sampling distributions (centered at \$605,675) which are obtained as sample sizes are increased. This qualitative statement provides, of course, a good deal less information for prediction and guidance than does the central limit theorem. The latter provides quantitative results as well as precise statements about when this kind of behavior can be expected to occur.

OR and Statistics

It would be possible to multiply examples of statistical applications to OR problems. Even in sampling theory (which is only one subdivision of statistics) and in accounting (which is only one subdivision of business and government), recent years have witnessed a growing number of successful applications.⁶ Indeed, the preceding example and illustration were drawn from a series of successfully executed studies being conducted jointly by Carnegie Institute of Technology and Touche, Niven, Bailey & Smart.⁷

Even though the science of statistics represents an important OR tool—possibly the most important one at the present stage of OR development—it would be a mistake to equate the statistical specialist and the worker in operations research. Operations research work may make it advisable to include a statistical specialist on the team. The presence of this specialist does not suffice to secure performance of a good quality of operations research, however essential statistical competence may be to the assignment in question.

The responsibilities of the OR worker may most easily be classified by considering, for a moment, the role of the engineer in design. The basic responsibility of the former may be said to resolve about the synthesis of the conceptual models for stating and solving management problems in a manner analogous to the way the traditional design engineer is presumed to incorporate management objectives in his blue prints and "mock ups". As in other lines of engineering, the ingredients of the OR design should be selected and adapted to reflect the best that scientific knowledge makes possible in achieving basic managerial

⁶ For references see R. M. Trueblood and R. J. Monteverde, "A Bibliography on the Application of Statistical Methods to Accounting and Auditing", THE ACCOUNTING REVIEW, XXIX, No. 2, April, 1954.

⁷ Robert M. Trueblood and R. M. Cyert, "Statistical Sampling Applied to Aging of Accounts Receivable", JOURNAL OF ACCOUNTANCY, March, 1954 and also Robert M. Trueblood and W. W. Cooper, "Research and Practice in Accounting and Auditing", to be published in THE ACCOUNTING REVIEW, XXX, April, 1955.

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objectives. Failure to reflect either essential managerial requirements or scientific opportunities in his models should be counted a shortcoming in any OR worker. The OR worker need not, of course, have full command of every phase of science. He, like other engineers, may call upon more specialized talents for his team, as required. He should not, however, fail to recognize when these talents are required; nor should he fail to integrate them properly in his overall model.

Types of Models

Preceding sections of this paper have dealt with models closely associated with data analysis. Data analysis is not an end in itself as far as business is concerned. Business data are collected and analyzed either because the process of collection and analysis is itself a control mechanism⁸ or because the results are required for explicit consideration in reaching decisions. A common example of the former is the emphasis on foreman-prepared budget submissions in order to secure more adequate guarantees of conformance. A common example of the latter is the use of consultants' reports on marketing problems and possibilities in various product lines.

While the above examples of statistical applications could be extended beyond data analysis in order to include specific consideration of decision elements it seems best to turn, instead, to another tool to show how OR may aid in the process. An OR tool which can be used to exhibit the process of decision making is supplied by linear programming. This is one of a kit of closely associated and recently developed scientific tools for handling large, complicated problems where the objective is to determine a "best possible" or "*optimum*" solution. The word optimum is underscored in order to emphasize the fact that procedures (or models) which yield "reasonable" or "satisfactory" solutions are not necessarily adequate for purposes of optimization.

The matter may be put in sharper focus by contrasting "optimization" and "simulation" models. The latter term can be used to designate a variety of commonly employed systems of business analysis and direction. A good example is supplied by production line scheduling or loading. Usually the scheduler follows a set routine under which he first attempts to get all of his orders onto the machine and assembly lines. The first trial usually overloads some parts of his process and underloads others. Considering the unit times and capacities (determined by management engineers and production experience) for his machines and processes to represent (or simulate) adequately the realities of production, the scheduler then attempts to balance by

⁸ This point needs specific mention because preoccupation with the decision making progress has led to some neglect of these control functions in the OR literature. I.e. the process of requiring subordinates to prepare reports on their activities may itself perform a control function influencing the behavior of these subordinates. This is a subtle but important function of many accounting reports, for example, as distinguished from the use of such reports by superiors as a basis for decisions to guide the behavior of subordinates. See C. West Churchman and Russell L. Ackoff, "Operational Accounting and Operations Research", THE JOURNAL OF ACCOUNTANCY, February 1955.

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shuffling the loads until his production requirements fall within the possibilities indicated by these times and capacities. At this point he may begin to introduce considerations, such as cost of production, inventory storage, etc., in order to achieve a better program which is also balanced. After the scheduler has satisfied himself that little is to be gained by further adjustment, the process of improvement is brought to a halt. There is no guarantee, of course, that the least costly program will have been achieved. If the variables to be considered are numerous or if the situation contains novel elements, it is fairly certain that these trial-and-error procedures will fall short—possibly far short—of an optimum.⁹

Both types of models—optimization and simulation—abstract certain elements from the real situation and place them into certain types of relations which facilitate analysis. It might be thought that the process of simulation, if carried far enough by numerous trials and errors, will emerge into the same result as a direct optimization. This is not necessarily the case. First, it may not be possible to carry the trial and error process through to an optimum because the roundabout character of these methods may require a huge number of calculations to achieve the result.¹⁰ Second, it is not necessarily true that optimization and simulation models will consider the same variables or relate them in the same manner. In any event it is best to be clear about which type of model is desired in order to attain the desired results in the most certain and economical manner.

Linear Programming—A Transportation Example

A powerful new tool, in the form of linear programming, has been made available for optimization analyses in OR work by the scientific advances of the last 10 to 15 years. This tool may be discussed in summary fashion by utilizing an example which has been published elsewhere in full detail.¹¹ The case in point involves the transportation of goods in required amounts from a set of origins where they are available, to a set of destinations where they are required. The objective is to effect the transport from origins to destinations at lowest total cost.

It is assumed that the data are available and are as portrayed below.

⁹ For a discussion of these points see A. Charnes, W. W. Cooper, and B. Mellon, "Blending Aviation Gasolines—A Study in Programming Interdependent Activities in an Integrated Oil Company", *ECONOMETRICA*, 20, No. 2, April, 1952; and A. Henderson and R. Schlaifer, "Mathematical Programming—Better Information for Better Decision Making", *HARVARD BUSINESS REVIEW*, May-June, 1954.

¹⁰ In this connection it may be noted that the absence of an explicit criterion of optimization means that the process of calculation does not terminate when an optimum is reached. Literally all possible solutions are required (possibly an infinite number) in order to determine whether any one solution (or schedule) is truly better than all the rest—i.e. optimal.

¹¹ A. Charnes and W. W. Cooper, "The Stepping Stone Method for Explaining Linear Programming Calculations in Transportation Type Programs", *MANAGEMENT SCIENCE* 1, Oct., 1954.

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TABLE II

Transportation Data

Amounts Available (row totals) and
 Amounts Required (column totals) and
 Unit Costs of Shipment (row and column intersections).

Destina- Origins	D ₁	D ₂	D ₃	D ₄	D ₅	Total Available (Tons)
	Amount Cost of Transport					
O ₁	2	1	2	3	3	5
O ₂	2	2	2	1	-1	5
O ₃	3	3	2	1	2	6
Total Required (tons)	2	2	4	4	4	16

The data of the table show the amounts of a certain commodity which a particular company has available at each of three origins, O₁, O₂, and O₃. There are 5 units available at O₁, 5 at O₂ and 6 at O₃. The total of 16 units is to be shipped to each of 5 destinations, D₁, D₂, D₃, D₄ and D₅. The cost, per unit, of making the shipments is indicated at the intersection of each row and column. Thus, it costs \$2 per unit to ship from O₁ to D₁, \$1 per unit to ship from O₁ to D₂, and so on. The problem of linear programming (and presumably a traffic manager) is to move the goods from the origins to the destinations at lowest total cost.¹²

Table II may be thought of as an abstract model of the kind commonly employed by traffic managers to facilitate their consideration of shipping schedules. Abstract models have, of course, been employed in business long before the advent of operations research.¹³ It is the ability to put these models in a form which provides immediate (and convenient) access to scientific progress that constitutes the element which OR adds.

To obtain access to the instruments of linear programming, for example, the OR worker might begin by translating Table II into the following mathematical model:

¹² Route O₂ to D₅ has a "negative" cost of \$1 per unit. It may be thought of as a subsidy for shipments over this route. It was inserted in the original problem—see reference cited in footnote 11—to show how linear programming might be used to evaluate the desirability of constructing facilities which would be necessary to obtain this subsidy.

¹³ Business has used (and continues to use) both abstract and concrete models. The former consists of a representation in symbolic form of selected elements of a problem or situation along with accompanying rules of manipulation and interpretation. In this connection one might think of a chart of accounts with a defined code and accompanying rules for making entries as a model for synthesizing and analyzing the underlying records and documents, etc. Concrete models on the other hand consist of a physical portrayal of selected elements, usually on a scale-to-scale basis. In this connection one might think of the usual models of ships or buildings. Scale models for studying floor layout and work planning are examples of concrete models which are in common industrial usage. Although only abstract models are considered in this paper there is no reason why concrete as well as abstract models cannot be employed where they can serve either to clarify the problem or give more immediate access to scientific knowledge.

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$$\begin{array}{rcl} x_{11} + x_{12} + x_{13} + x_{14} + x_{15} & = & 5 \\ x_{21} + x_{22} + x_{23} + x_{24} + x_{25} & = & 5 \\ x_{31} + x_{32} + x_{33} + x_{34} + x_{35} & = & 6 \\ x_{11} + x_{21} + x_{31} & = & 2 \\ x_{12} + x_{22} + x_{32} & = & 2 \\ x_{13} + x_{23} + x_{33} & = & 4 \\ x_{14} + x_{24} + x_{34} & = & 4 \\ x_{15} + x_{25} + x_{35} & = & 4 \end{array}$$

The first equation states that the sum of the x 's, or unknowns, to be scheduled from the first origin (indicated by the first subscript) to each of the five possible destinations (indicated by the second subscript) must equal five (tons)—i.e., the amount available at O_1 . Similar remarks apply to equations two (the second origin) and three (the third origin). The remaining 5 equations are then obtained by adding down the columns to state the condition that the amounts to be scheduled over the indicated routings must, when summed, be equal to the amounts required at each of destinations 1, 2, 3, 4, and 5, as indicated by the second subscript in these equations.

The above equations state only part of the problem. The total cost of any program may be obtained by multiplying the unit cost for each route by the amount to be shipped over that route and summing to obtain¹⁴

Total Cost

$$\text{of} = 2x_{11} + x_{12} + 2x_{13} + 3x_{14} + 3x_{15} + 2x_{21} + \dots + 2x_{35}$$

Any Programme

The objective is to determine which values of the unknowns that meet the conditions of the problem and also make this total cost a minimum. Statement of this objective and prescription of an operable procedure for discovering these values is an integral part of the problem of linear programming—as it should be for the traffic manager. Another element of the problem which should receive explicit statement is the fact that only non-negative values of the x 's are admissible. In the language of traffic management this may be interpreted to mean that only shipments from origins to destinations will be considered. Shipments in the reverse direction are not permitted.

It should be clear that numerous schedules may be made up which meet the requirements portrayed in Table II or its equivalent set of equations without fulfilling the minimum total cost objective. Consider, for example, Table III, where the cell intersection convention indicates the routings from particular origins to destinations. The operations researcher using his mathematical tools might express this same

¹⁴ The ellipsis (...) means continue forming the missing terms (by reference to Table II) in the same manner in which preceding and succeeding terms were found.

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"solution" as follows:

$$x_{11} = 2$$

$$x_{23} = 3$$

$$x_{34} = 2$$

$$x_{12} = 2$$

$$x_{24} = 2$$

$$x_{35} = 5$$

$$x_{13} = 1$$

and all other x 's equal zero.

The total cost of this program is \$26, as determined by applying the rates of Table II.

$$2 \times 2 + 2 \times 1 + 1 \times 2 + 3 \times 2 + 2 \times 1 + 2 \times 1 + 4 \times 2 = \$26.$$

Is this the best that can be done? The traffic manager might experiment with trial solutions, compare results until he reached a "satisfactory" level. He would then choose the best one of his various trial solutions—i.e., those trial solutions which also fitted the other requirements of his problem.

TABLE III

Destina- Origins	D ₁	D ₂	D ₃	D ₄	D ₅	Total Available
0 ₁	2	2	1			5
0 ₂			3	2		5
0 ₃				2	4	6
Total Required	2	2	4	4	4	16

In large-scale problems the traffic manager's trial and error methods could not guarantee that he had, in fact, obtained the best possible solution. The methods of linear programming, on the other hand, guarantee this result no matter how large the problem may be. In the present example, a least-cost program which meets the requirements is portrayed in Table IV.

TABLE IV

Destina- Origins	D ₁	D ₂	D ₃	D ₄	D ₅	Total Available
0 ₁	2	2	1			5
0 ₂			1		4	5
0 ₃			2	4		6
Total Required	2	2	4	4	4	16

The total cost of this program is \$14, or \$12 less than the previous trial and error solution—viz.:

$$(2 \times 2) + (2 \times 1) + (1 \times 2) + (1 \times 2) + (2 \times 2) + (4 \times 1) + (4 \times (-1)) = \$14.$$

It should, perhaps, be noted that other equally good programs are available, and that linear programming provides a means for locating them as well as for determining second best programs, third best programs, etc. Flexibility is thus provided as well as rigor and routinization.

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It may be thought that applications of linear programming may be impeded because of the formidable barriers provided by the need for mastering higher mathematics. Understanding of the underlying mathematical theory is, of course, required for original problem development and model formation. It is not required for effecting calculations. In practice the methods of most traffic managers are more difficult to teach than the methods of linear programming. An ordinary clerk can be taught how to apply these methods skillfully and rapidly in less than an hour's time.¹⁵ In the H. J. Heinz Company, for example, where linear programming methods are now employed to schedule freight from some 17 origins to more than 50 destinations the entire calculations are handled by an ordinary comptometer operator.¹⁶ The methods previously used required the full-scale attention of managerial personnel who could not objectify their methods, judgment and experience sufficiently to effect a delegation to the clerical level.

It is perhaps well to emphasize that linear programming is not restricted to transportation scheduling.¹⁷ Many other successful applications have been made, which range from machine loading in job-shop operations to refinery schedules in a continuous process. Operations for an entire company, including purchasing, production, transportation and marketing have been comprehended in one integrated model. Other examples might also be cited in which statistical analysis of unknown or imperfectly forecasted elements are synthesized and joined with linear programming in one integrated approach.¹⁸ Syntheses with other OR tools, in addition to statistics, are also possible. Continuing research may be expected to yield not only new applications but new tools and further extension as well.

Conclusions

After this rather lengthy exposition it may be well to conclude by an attempt at recapitulation. The objective has been to provide an exposition by means of which the subject of operations research might be understood and evaluated. The development therefore proceeded as follows: After attempting to place the field of operations research in the historical perspective of predecessor disciplines in business—particularly management engineering—and noting its relation to basic science, an attempt was made to show how operations research differed from these other disciplines. The main difference, it was noted, lay not in the problems but in the methods (or tools) employed by com-

¹⁵ An explanation of these methods may be found in the references cited in footnote 11. See also G. B. Dantzig, "Application of the Simplex Method to a Transportation Problem", Ch. XXIII, in *ACTIVITY ANALYSIS OF PRODUCTION AND ALLOCATION*, T. C. Koopmans, ed. (New York: John Wiley and Sons, 1951.)

¹⁶ See A. Henderson and R. Schlaifer, *OP. CIT.*, reference cited in footnote 9.

¹⁷ See A. Charnes, W. W. Cooper and A. Henderson, *AN INTRODUCTION TO LINEAR PROGRAMMING*, (New York: John Wiley and Sons, 1953) for a general introduction to the subject.

¹⁸ See A. Charnes, W. W. Cooper and R. Ferguson, "A Method for Determining Executive Compensation to Meet Company Organization Requirements", *MANAGEMENT SCIENCE*, January, 1955.

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petent OR personnel and in the accompanying points of view.¹⁹ For this reason selected OR tools from statistics and linear programming were used for purposes of illustration. It was deemed best, moreover, to discuss these tools in the context of specific business problems in order that their possibilities and limitations might more easily be comprehended. The point made in each case was that the problems, such as improved transportation scheduling, improvement of clerical routines, etc., fall within the traditional ambit of management engineering activities in business, but that the methods used by the OR specialist differed in important respects from those previously used in solving these kinds of problems.

It must not be thought, however, that these problems or tools exhaust the repertoire of the capable OR analyst. The currently available tools that modern science has made available for these kinds of problems are too numerous to be detailed here. Moreover, as problems from the world of business are fed back into the basic sciences further stimulation and development can be expected.²⁰ The vehicle by which this will be accomplished is provided by the kinds of models that the OR worker is able to synthesize. These models perform, therefore, the same function that design consideration do in other engineering fields. They provide a means by which scientific knowledge is fed into the world as well as a means by which the problems of the world are fed back into science.

A defect of many operations research workers that needs to be overcome, is their lack of business experience and familiarity with the languages and problems of business. Their usefulness to business as well as to science will be enhanced as this deficiency is overcome. It is to be hoped, however, that they will not make the mistake of following the path taken by management engineering—viz., attenuating their relation to research in basic science as they seek to serve business to the utmost. If this mistake is made, it is possible to predict that progress, though retarded, will continue to be made. At some later date another "OR development" will then confront the consolidated management engineering profession.

FOR FURTHER READING:

- ENTER OPERATIONS RESEARCH—John F. Magee, N.A.C.A. Bulletin, June '54.
OPERATIONS RESEARCH FOR MANAGEMENT—Hermann & Magee, Harv. Bus. Review, July-Aug., 1953.
OPERATIONS RESEARCH, Churchman & Ackoff, Jrnl. of Acctey., Feb., 1955.
OPERATIONS RESEARCH—A TOOL OF MANAGEMENT, E. J. Thomas, Jr., N.A.C.A. Bulletin, Dec., 1953.

¹⁹ The point was also made that this difference also placed the OR worker in a more intimate relation to basic science.

²⁰ An example is afforded by the recent formation of a new professional society, The Institute of Management Sciences, many of whose members are devoted to these kinds of advances.

Student Section . . .

This is the third of the papers prepared and presented by Student members at the January meeting of the Calgary Chapter.

FUNDAMENTALS OF COST ACCOUNTING AND ADVANCED COST ACCOUNTING

By ADRIAN SMITH

Cost accounting is the science of recording and presenting business transactions pertaining to the production of goods whereby these records become a method of measurement and a means of control. It embodies the analysis and grouping of cost transactions in such a manner that it is possible to disclose the total production cost of a commodity or a job, in addition to their cost element make-up in terms of material, labour and factory overhead costs. It also includes an analysis and grouping of the total cost of production in terms of department, cost center, and manual and machine operation costs.

In other words, cost accounting is the branch of general accounting dealing with:

- (1) Detailed cost analysis and study.
- (2) The determination of unit costs.
- (3) The computation of costs of raw materials used, goods completed, and goods sold without taking physical inventories.

The difference between cost accounting and general accounting is largely a matter of emphasis on detailed cost analysis, dealing with unit costs on a current basis and the use of the perpetual inventory system. The operation of a successful cost accounting system requires a careful analysis of the information available, a proper interpretation of this analysis, followed by action on this interpretation by management.

There are several features of cost accounting that set it apart from general accounting.

- (1) The books of account are closed out in entirety—usually once a month, whereas in general accounting this is done once a year.
- (2) All costs are charged directly to the product when possible.
- (3) Indirect costs are reclassified into departmental costs.
- (4) Controlling accounts in the general ledger supported by detailed subsidiary ledgers are used to a greater extent in cost accounting.
- (5) Perpetual inventory accounts are maintained, the balances of which are checked regularly by physical count and adjusted.
- (6) The purchase of labour, material and services is regarded as purchase of assets and not treated as expense, as in general accounting. These assets—material, labour and services—are converted into another asset, "Work in Process", and from that to another asset, "Finished Goods", and then to "Cost of Goods Sold". The "Cost of Goods Sold" is converted to the asset "Cash", which is used to begin the cycle of material, labour and services again.

In the prescribed course of studies of the Society of Industrial and Cost Accountants, the subject, "Fundamentals of Cost Accounting" serves as the introduction to this specialized system of recording and sorting the available information. The first part of the course is concerned mainly with acquainting the student with the fundamental procedures peculiar to cost accounting. The process of cost accounting consists largely of assorting and reassorting cost data into different classifications that serve useful purposes. In this process, costs are classified in various ways and, at different steps in the cost accounting process, the same cost figures may be placed in different classifications. An understanding of cost classification is, therefore, necessary to master cost accounting.

The course gives a thorough explanation of the purchasing, receiving and handling of materials. This is necessary in order to gain an understanding of the detailed analysis and controls necessary for the operation of an efficient cost

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accounting system. It explains the interlocking control that is maintained over the materials and their costs from the time of the order for the materials until they emerge in the finished product. Different methods of valuing inventories are discussed as well as the necessity of inventory controls. The difference between direct and indirect materials is important so that proper classification of costs can be made once the materials leave the inventory stock-pile.

Like accounting for materials, labour costs require a thorough understanding—from the forms for recording time and cost to the final classifications. The necessity of a quick, efficient method of arriving at labour costs is a prime requisite if a successful system is to be maintained.

Manufacturing or overhead expense is the element of cost which requires a great deal more study than the method of accounting for materials and labour. Material and labour costs are quite easily classified to product, departments or cost centres from the material requisition forms and labour time cards. However, such is not the case with overhead expenses. Each of these expenses must be analyzed and apportioned correctly to the departments or divisions, according to the amount of benefit derived from the expense item. For instance, the electric bill for a month may be for the entire plant. This cost must be allocated between the administrative, selling and manufacturing divisions of the business. In the manufacturing division it must be further allocated according to the service rendered—as a direct cost of a producing department for the amount used to operate production machinery as a direct cost to a service department for the amount used to operate the power tools required for repairs and maintenance, and as an indirect cost which must be allocated to the producing and servicing departments by some equitable method, for general lighting of the plant, washrooms, lunchroom, etc. Because of the steady trend towards mechanization in present day production, overhead costs have become the foremost factor in arranging production schedules, the volume of production and competitive selling prices.

The course in Fundamentals of Cost Accounting introduces the two basis types of cost systems:

- (1) The Process Cost System.
- (2) The Job Order Cost System.

A Process Cost System is one in which costs and quantities of production are collected by departments, and the departmental costs are reduced to a cost per unit of production from which the average cost of any quantity of product may be computed. The use of a process cost system requires that the product shall be manufactured in a continuous stream without necessarily being divided into different lots or quantities or otherwise being marked for separate identification. Examples of industries using this process cost system are paper-making, flour milling and textile manufacturing. It is used in these industries in which the finished product is the result of a series of successive operations, each following continuously after the preceding operation. The product is a result which comes from the various operations performed on an original material with the possible addition of other materials.

The introduction of process cost accounting introduces the first deviation from theory in the Fundamentals of Cost Accounting course. Because of this, it is not only necessary to understand the accounting theory, but to apply it to specific given problems. Examination papers usually contain at least one mathematical problem requiring journal entries for a process cost system. Any question of this type can be solved if the four principles of process cost accounting are remembered.

- (1) Raw materials, direct labour and manufacturing expenses are charged direct to the departments in which they are used.
- (2) Unit costs must be ascertained for each department.
- (3) The cost must follow the production. This means that as the product travels from one department to another, the cost accumulated on it in previous departments must be transferred to the accounts of succeeding departments if the complete cost of the finished product is to be secured, or if the cost at any stage of production is to be known.

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- (4) The valuation of inventories of unfinished work at the close of the period in each production department are estimated by means of the method of "production in terms of finished units".

The Job Order Cost System is used in industries whose operating methods and cost requirements are such that it is necessary to secure costs for different jobs or lots of work, as well as for departments. Examples of this type of industry are the manufacture of machinery and job printing. In the Job Order Cost System, costs are obtained for each separate lot of product manufactured in addition to costs of operating each manufacturing department. It is necessary for the operation of this system that the product should be manufactured in separate lots of clearly distinguishable quantities. The outstanding reason for the use of a specific order cost system is that the difference between each lot of product manufactured is such that any attempt to average the cost of two or more unlike lots would result in an inaccurate statement of the cost of each lot.

In doing problems of the Job Order Cost type, the main points to remember are these:

- (1) Direct materials and direct labour are charged to the work in process account of the job being done.
- (2) Indirect costs are charged to the department in which they were expended.
- (3) These indirect costs are applied to each job by some arbitrary method, the total of which does not necessarily agree with the actual expenses for the month.
- (4) Whether a job is completed or not at the end of an accounting period, it is charged with a share of the indirect costs.

This is not a complete resume of the course of studies in Fundamentals of Cost Accounting, but the theory in the course evolves itself into the two basic types of cost systems.

- (1) The Process Cost System.
- (2) The Job Order Cost System.

A thorough knowledge and understanding of these two systems which are, in fact very similar, will give any student a firm foundation in the study of cost accounting and indeed, will be found to be an absolute necessity for an understanding of advanced cost accounting.

The final year subject of Advanced Cost Accounting is a detailed study of standard cost, variances and budgets. It emphasizes the terrific advantage of predetermined costs and forecasts as a control factor for management. A standard cost for a unit of product poses no great accounting problem. The procedure is quite similar to using the actual costs. However, the resulting variances and the reasons for them are the major findings that a standard cost system aims to achieve. Therefore, before solving any problem using standard costs, a thorough knowledge is required of the different variances and what causes them. For instance, in an industry that uses standard costs, a small material variance may have resulted. At first glance the variance may seem too small to cause concern. However by analyzing it into price variance and volume variance, it could be discovered that the actual materials put into process were purchased at a great saving compared to the standard cost for the same material; while on the other hand, a great deal more material was used than the predetermined standard called for. Thus a favorable price variance was offset by an unfavorable volume variance. With this picture before them, management can pin-point below-standard operations and take corrective measures.

The same applies to direct labour. By analyzing the labour variances, it can be discovered what portion is due to differences from standard wage rates, and the portion due to above standard efficiency or below standard inefficiency, as the case may be.

Manufacturing expense variances are exceedingly important. As each item of expense is capable of being classified as fixed, variable or a semi-variable expense, a very close analysis of this variance is necessary. For instance the foreman of the

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repairs and maintenance department could not be held responsible for increased costs resulting because the employment department sent him specialists instead of labourers but he would be held accountable for excessive labour costs resulting from lack of supervision. The primary purpose of expense analysis is to segregate expense components in order to measure operating efficiency. To enable the analyst to segregate the cost elements, he must understand what goes into an expense account. That is, he must be fully aware of how for instance, standards are arrived at, how accounts are classified and expenses accumulated. With this knowledge the resulting figures can then be unscrambled to arrive at basic facts.

Tied in with any successful standard cost system are budgets, which require a great deal of research to prepare, but are of infinite value in the guidance of the business.

One of the better ways of obtaining a clearer grasp in handling any cost accounting problem is to work out the questions in the Student Section of the Monthly Cost & Management Magazine. By comparing your answers with those shown it helps to develop the art of recognizing and using the available information. This is quite important in examination questions when working against a time limit—not to waste valuable time calculating information which is already given in the problem or else not required in the answer.

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